

## **Workshop Research Recommendations**

### **Fundamental Chemical Processes and Optical Properties**

- Theoretical optical property prediction
- Map the chemical composition changes that transform hydrophobic BC into hydrophilic
- Track changes in optical properties of mixed aerosols as function of RH
- Define effects of combustion aerosols on cloud microphysics
- A priori prediction of atmospheric residence time/fate/half-life of BC aerosols
- Determine scavenging rates of individual aerosol components
  - Note: this can be related to aerosol indirect effects
  - Question: can scavenging rates by chemical species be weighted according to aerosol fraction and summed to give the effective scavenging rate for a given population of aerosols?

### **Source Measurements**

- Continued measurement (and compilation) of carbonaceous aerosol optical properties (absorption and scattering coefficients, indices of refraction)
  - Source-specific
  - Ambient
  - Lab-generated
  - As function of coating or mixing with other aerosol types
- Characterize aerosol composition and optical properties from source to downwind (aging), especially the atmospheric residence time of BC aerosols, especially
  - Light-duty vehicles
  - On and off-road vehicles, in use (accounting for road conditions)
- Special case studies
  - Off road: within construction sites and within gravel pits
  - For uncooperative sources, exploit new developments in ambient measures adjacent to sources to establish profiles/fingerprints
- Resolve relationships between OC/EC/BC and thermal/optical properties as a function of source
- Measurement of hygroscopicity of freshly emitted aerosols
- Characterize missing sources: rail, marine, aviation, others

### **Ambient Measurements**

- Vehicle chase measurements of OC/BC, PM<sub>2.5</sub>, NO<sub>x</sub>
  - Before and after after-treatment (off-road diesel?)
- Compilation/inventory of existing satellite and in situ global aerosol measurements

- Global BC measurement campaign to fill in gaps
  - 3D ambient measurements of BC downwind of Indian and other Asian sources
  - Vertical profiles of OC/BC/EC on a regional basis (if reasonable)
  - Measurements of BC above clouds
- Multi-scale integration (satellite, in situ, surface) of measurements with models, focusing on urban scales
- Simultaneously track the following specific properties of ambient aerosol fractions as a function of age (at source to downwind to atmospheric removal)
  - Chemical mixing state
  - Optical properties as a function of wavelength
  - OC/EC/BC fraction
  - Hygroscopicity
- BC concentrations in snow (temporal variation)
- Specific studies:
  - Chemical-optical closure measurements for sources and source/dominated regions
  - Source apportionment in key Chinese and Indian cities

#### Measurement Techniques/Standards

- Studies
  - Intercomparison of all current OC/EC/BC measurement techniques
  - Produce a catalog of source measurements the most important measurement methods and correlate OC/EC/BC detected by each
- Standards
  - Develop an international standard set of measurements, packaged for field deployment
  - Develop a catalog of carbonaceous reference materials with their properties according to current measurement methodologies, including chemical and optical
  - New measurement standard for EC/BC based on light absorption
- Techniques/instruments
  - Method for measuring BC in water (needed to resolve BC carbon budget deficit)
  - Multiangle/multispectral polarimetric imager (satellite-based)
  - Expand existing in situ measurement methods for aerosols, in general, and BC, in particular
  - Time-of-flight mass spectrometer (TOFMS) to study fresh vs. aged in-use vehicle emissions
  - Portable emissions rate meter for PM, especially for total carbon, EC/OC

## Inventory Development

- Compile and evaluate all available emissions and activity factors
  - Convene an international version of the US EPA EIIP?
  - Rigorously quantify and propagate uncertainties (emissions and activity factors, etc)
  - Lab and in-use emissions factors reconciled
  - Biomass combustion in all forms, i.e. Indian cook stoves, etc.
- Validation of BC emissions against inter-annual and longer-term trends
- Validation of BC inventories against ambient concentrations
  - Special case: Observed concentrations at single-source dominated sites
  - Focused intercomparison of Central California satellite, aircraft and modeled inventories
- Continued development of
  - Global BC emissions inventories (China and India as top priorities)
  - Global on- and non-road mobile sources inventory (plus a fleet count)
  - Complete suite of on- and non-road diesel/gas emissions factors and source profiles
    - As function of ambient temperature
    - “Cold start” conditions
    - Modified/tampered w/ gasoline vehicles
    - Adulterated fuels
    - Developing country vehicle fleets, especially!
- Reconciliation of bottom-up and top-down regional inventories
- Overall evaluation of uncertainties and accuracy of emissions inventories
- Estimation tool for region-specific vehicle emissions
- Guidelines for estimating BC fraction of mobile source emissions
- Biogenic emissions models for DMS, organics, vegetation
- Sectoral/technology-specific analysis of emissions (assess completeness of available data for each)

## Other Climate Model Inputs

- State Implementation Plan-projected PM emissions used as regional climate modeling inputs
- Use other urban/regional air quality models to provide climate modeling inputs

## AQ/Climate Modeling and Aerosol Source Apportionment

- Needed Capabilities
  - Temporal variability of BC emissions
  - Ice/snow wavelength-dependent albedo changes with BC deposition

- Aerosol mixing → optical property predictive capability
- Evolution of aerosol optical properties from urban to global scale
- Integration of urban/regional scale features into global scale models
- Incorporate satellite data into modeling carbonaceous aerosol indirect effects
- Modules that calculate aerosol mixing and aging
- Sensitivities
  - Carbonaceous aerosols on cloud properties
  - Clouds to climate change and vice versa
  - Climate forcing to aerosol microphysics/concentrations
  - Climate to OC
  - Climate to BC
    - Sensitivity to particle size and number, i.e. before and after diesel particle trap filtration
    - Sensitivity to particle aging in GCMs
  - Climate to EU and US SO<sub>x</sub> emissions reductions
  - Climate forcing associated with individual sources/technologies
  - Improve climate forcing potentials for different classes of aerosols
- Intercomparisons/evaluations
  - Regional climate models
  - Coupling between regional and global-scale climate models
  - Determine source of the discrepancy amongst climate models in
    - aerosol/BC loadings (Inventories used? Chemical mechanisms?)
    - predicted forcings
  - Determine source of discrepancies in modeled versus measured interannual/interdecadal variability in BC
  - Source apportionment techniques, in general
  - Source apportionment techniques for inventory validation
  - Compare source apportionment studies with modeled predictions

### Other Recommendations

- More interdisciplinary technical exchange workshops
- Strengthen international scientific collaborations
  - US/Canadian collaboration on OC/BC
- Report on the role of carbonaceous aerosol on climate for non-scientists